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# **PROPULSION DIRECTORATE**

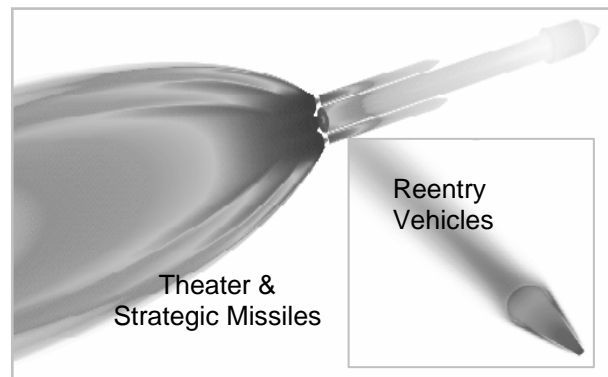
## **Monthly Accomplishment Report January 2006**

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**PLUME SIGNATURE RESEARCH ENABLES MISSILE DEFENSE:** Air Force programs such as SBIRS-high,<sup>\*</sup> as well as numerous [Missile Defense Agency](#) (MDA) programs (e.g., STSS, BPI, THAAD),<sup>†</sup> rely on an accurate knowledge of the target or threat missile signature for all stages of flight. AFOSR-sponsored research at AFRL's Propulsion Directorate and various universities has been transitioned to users of these programs for interceptor and algorithm development. Simulation and prediction of vehicle flowfields and plume radiation signatures at high altitudes require a specialized numerical tool known as direct simulation Monte Carlo (DSMC). AFOSR-sponsored basic research at the University of Michigan, Pennsylvania State University, and AFRL/PR over a sustained period has created and improved approaches to include vital real-gas properties in the DSMC technique. Furthermore, methods to increase simulation efficiency and utilize computer clusters have been devised so that simulations of expensive realistic problems are becoming feasible. Sophisticated verification and validation studies of a range of physical models for DSMC have been produced. Flow and signature predictions can now be produced an order of magnitude faster and with much higher fidelity compared to just five years ago. While basic research is on-going for next-generation additions such as including particulates (e.g., soot, aluminum oxide, or fuel droplets) within the gas-flow simulations, substantial capabilities have already been transitioned. [Spectral Sciences, Inc.](#) has utilized Small Business Innovation Research (SBIR) contracts and DoD advanced development funds to modernize SOCRATES,<sup>‡</sup> its DSMC tool, and incorporate the latest research results in a highly-capable and usable package. AFOSR basic research is transitioned by AFRL/PR through their model development and applications efforts supported by MDA and other DoD customers. The SOCRATES package is being used by Air Force and MDA users to answer pressing questions on plume signatures needed for interceptor algorithms, sensor design, and more. (Dr. Mitat Birkan, AFOSR, (703) 696-7234, Mr. Thomas Smith, AFRL/PRSA, (661) 275-5432, Dr. Ingrid Wysong, AFRL/PRSA, (661) 275-5206)



**MARS ROVERS MARK TWO-YEAR ANNIVERSARY:** AFRL's Propulsion Directorate has played a role in the remarkable longevity of the Mars Rovers *Spirit* and *Opportunity*, which recently marked their two-year anniversary on the red planet. *Spirit* arrived on Mars on 4 January 2004, and *Opportunity* arrived three weeks later on 25 January 2004. Though both Rovers were expected to operate on the surface of Mars for about 90 days, they have now exceeded that expectation by a factor of more than eight. AFRL/PR played a key role in the development of the lithium-ion battery technology that helps power the rovers on the Martian surface. These lithium-ion batteries keep the Rovers "alive" at night and provide additional power during intensive daytime operations. AFRL/PR planned and managed the lithium-ion battery R&D program that established the cell chemistry and cell design for these batteries, with cooperation and funding

<sup>\*</sup> SBIRS = Space Based Infrared System

<sup>†</sup> STSS = Space Tracking and Surveillance System; BPI = Boost Phase Intercept; THAAD = Theater High Altitude Area Defense

<sup>‡</sup> SOCRATES = Spacecraft/Orbiter Contamination Representation Accounting for Transiently Emitted Species

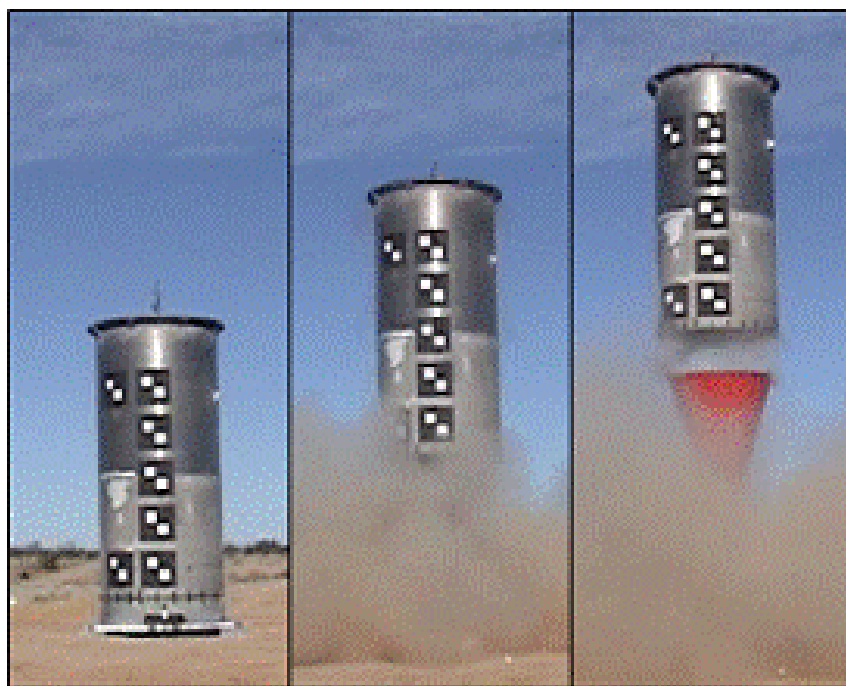


A Rover on the surface of Mars

from NASA's Jet Propulsion Laboratory (JPL) and the Army. (Mr. Stephen Vukson, AFRL/PRPS, (937) 255-5461)

FALCON STAGE SEPARATION TEST SUCCESSFUL: Propulsion Directorate personnel supported a [full scale stage separation test](#) of AirLaunch LLC's QuickReach™ small launch vehicle on 13 January 2006 in Mojave, California. This test was the first major milestone of Phase 2B of the DARPA/Air Force [Falcon](#) program. The purpose of the test was to demonstrate that the separated first stage would not impact

the nozzle of the second stage during the separation event, and the test demonstrated that the innovative gas pneumatic stage separation technique developed by AirLaunch is practical and safe. Analysis of test video showed an acceptable clearance between the separated stage and the nozzle. Under the Falcon Phase 2B contract, AirLaunch and its team of subcontractors are continuing development of the QuickReach™ small satellite booster. The Falcon program goal is to develop a vehicle that can launch 1,000 pounds to orbit for less than \$5 million with only 24 hours notice. AirLaunch's design achieves this goal by carrying its QuickReach™ booster to altitude inside the cargo bay of an unmodified C-17A or other large cargo aircraft. (Mr. Eric Spero, AFRL/PRSE, (661) 275-5972)



Time lapse photo of the Falcon stage separation test

AEDC COMMANDER HONORS  
PROPULSION DIRECTORATE

TEAM: A Propulsion Directorate team was honored by Brigadier General David Stringer, Commander of the Arnold Engineering Development Center (AEDC), for work they performed to support AEDC in 2005. Brig Gen Stringer presented AFRL/PR's AEDC Spacer Test Team with certificates of appreciation and AEDC Commander's Medallions for their efforts. The Spacer Test Team played a critical role in bringing the AEDC 16-foot transonic (16T) wind tunnel back on-line after a problem was discovered in the facility's compressor. The Spacer Test Team performed tests in the [Propeller Test Facility](#) at Wright-Patterson AFB, Ohio, to examine repaired fan blade spacers for the compressor. The timely manner in which AFRL/PR completed the testing helped AEDC meet its own testing schedule. The team honored by Brig Gen Stringer consists of AFRL/PR's Mr. Gary Terborg and a group of on-site contractors with Taitech, Inc. that includes: Messrs. Todd Buckle, Harold Couch, Jim Haines, Alfredo Jimenez, Mike Sanders, Jack Seubert, and Greg Tackett. (Mr. Gary Terborg, AFRL/PROE, (937) 255-5839)



AEDC test article mounted in the Propeller Test Facility



AFRL/PR's AEDC Spacer Test Team was honored by Brig Gen David Stringer. Pictured (from L to R) are: Brig Gen Stringer, Jack Seubert, Alfredo Jimenez, Mike Sanders, Gary Terborg, Greg Tackett, Todd Buckle, and Jim Haines (not pictured, Harold Couch)

#### MR. HANNA HONORED FOR INTEGRATED POWERHEAD DEMONSTRATION WORK:

The Propulsion Directorate's Mr. Stephen Hanna was recently honored with the 2006 American



Mr. Stephen Hanna recently received the AIAA Liquid Propulsion Technical Committee Young Professional Award

Institute of Aeronautics and Astronautics (AIAA) Liquid Propulsion Technical Committee Young Professional Award. This award is presented to an individual who makes early achievements in liquid propulsion and demonstrates the potential for a successful career in the field. Mr. Hanna is a program manager in AFRL/PR's Space and Missile Propulsion Division (AFRL/PRS), and is being honored for his leadership role on the Integrated Powerhead Demonstration (IPD) program. This is a joint program involving government (Air Force and NASA) and Industry (Pratt & Whitney Rocketdyne and Aerojet), which successfully demonstrated the first operation of a full flow staged combustion cycle liquid rocket engine. Notably, Mr. Hanna was able to get the program back on-track after Hurricane Katrina made landfall near the IPD engine test site at NASA Stennis Space Center outside of Bay St. Louis, Mississippi. Remarkably, testing was able to resume within two months of landfall. Mr. Hanna will receive this award at the [42<sup>nd</sup> Annual AIAA/ASME/SAE/ASEE Joint Propulsion Conference](#) to be held 9-12 July 2006 in Sacramento, California. (Dr. Richard Cohn, AFRL/PRSE, (661) 275-6177)



Dr. Andrew Ketsdever received the Roger R. Bate Award for the Outstanding First-Year Instructor in the Department of Astronautics at the Air Force Academy

#### DR. KETSDEVER NAMED TOP NEW INSTRUCTOR BY AIR FORCE ACADEMY:

The Propulsion Directorate's Dr. Andrew Ketsdever was recently honored by the US Air Force Academy. Dr. Ketsdever received the Roger R. Bate Award for the Outstanding First-Year Instructor in the Department of Astronautics. Selected by a vote of the 18-member faculty, Dr. Ketsdever received this award for his demonstrated excellence as a teacher, mentor, and role model. His selection is notable, as he is the first non-active duty Air Force member to win the award. The award is named for Col Roger R. Bate, the first Permanent Professor of the Department of Astronautics at the US Air Force Academy. Col Bate is also well-

known as one of the authors of the widely-used textbook *Fundamentals of Astrodynamics*.<sup>§</sup>  
(Dr. Ingrid Wysong, AFRL/PRSA, (661) 275-5206)

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<sup>§</sup> Bate, Roger R., Mueller, Donald D., and White, Jerry E., *Fundamentals of Astrodynamics*, Dover Publications, New York, 1971.